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ABSTRACT

The influences of a student's prior knowledge and desired goal on the difficulties and benefits associated with using hypertext were examined in this study. Participants, 12 students from an undergraduate course in educational psychology, were assigned to either the low or high prior knowledge category. Within these two groups, subjects were randomly separated into strong and weak accomplishment goals. Students used the SKEIM program (a hierarchically structured hypermedia system) to accomplish their goals. After completing the tasks, students were interviewed. The first part of the interview involved questions related to feelings about use of the program in general. Students were then shown every step they made using SKEIM, and the researcher asked questions about the student's immediate goal or purpose at each branching point. Results showed that students tended to have more than just a cognitive reaction when learning from hypertext. High levels of anxiety were common for the low prior knowledge students, especially when required to perform a specific learning task. Implications are that hypermedia design aspects, in interaction with specific individual characteristics such as prior knowledge and goals, can promote negative affect which is non-productive for learning. Findings suggest that educational software developers should consider features of the audience before committing to a method of instructional delivery. (AEF)

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Using Hypermedia: Effects of Prior Knowledge and Goal Strength

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The study reported here was an interview study of low and high prior knowledge students with strong or weak goals exploring a hypertext stack. We examined the influences of a student's prior knowledge and desired goal on the difficulties and benefits associated with using hypertext. In-depth interviews were conducted with students who participated in the study.

A commonly recognized difficulty with hypertext is the possibility of getting lost or disoriented (Conklin, 1987; Edwards & Hardman, 1989; Hammond & Allison, 1989). This kind of disorientation often occurs when a user suffers from cognitive overload as a result of being confronted with a mass of links through which to navigate with little structural support (Giril & Luk, 1992).

Akanabi and Dwyer (1989) noted the importance of prior knowledge over text structure as students with varying levels of prior knowledge benefited from different types of text structure. Students with high prior knowledge profited most from a less structured, inductive learning environment while low prior knowledge students benefited most from a more structured, deductive environment. Similar results were found by Pazzini (1991) who showed that the rate of concept learning was affected more by students' prior knowledge than by a text's content structure. In general, prior knowledge can determine how well a learner acquires information from hypermedia since it can supply a mental framework, providing both perspective and context for new and inter-connected concepts, allowing a learner to fill in gaps in knowledge. Prior knowledge allows a learner to focus more directly on information presented by reducing the amount of overhead associated with the task of navigating through hypermedia. Without some kind of mental map of the material already in place, working memory can become overloaded as the user tries to understand all the information presented and how it is structured.

Alexander, Kulikowich, and Jetton (1994) concluded that it is important to consider how additional factors other than prior knowledge affect learners. One such factor is the goals that learners have. With many options available in a hypertext structure and all possible avenues equally available, students' goals must play an important part in the ease and effectiveness with which hypertext is used. In an ideal constructivist environment, hypermedia users would search for complex information to meet their own goals (Jonassen & Wang, 1993). However, external goals are often imposed on learners and even when the learners accept such goals, they may not have appropriate strategies available to them to attain the goals.

While goals and prior knowledge have been shown to affect linear text processing, very little research has been conducted on how these factors affect learners in a hypermedia environment. Because these factors have not been carefully considered in relation to hypermedia learning, research is still at the stage where rich descriptions are necessary in order to identify and explore relevant factors. Utilizing a qualitative methodology and small sample size, this study examined the influences of a user's prior knowledge and desired goal on the difficulties and benefits associated with hypermedia.

Method

Participants. Twelve subjects from an undergraduate course in Educational Psychology were recruited to participate in the study. Eight were female and four were male.

Materials. The study utilized a hierarchically structured hypermedia system, SKEIM, developed by A. Kelly (Kelly, 1993; Kelly & O'Donnell, 1994) which runs on the Macintosh platform and was developed using HyperCard Software. The program's content, organized by A. O'Donnell, contains material based on an undergraduate course in educational psychology on the subject of tests and measurement. Concepts were characterized using the sets of relationships identified by Dansereau and his colleagues (e.g., Holley & Dansereau, 1984). This classification of concepts was instantiated within SKEIM and was meant to provide an extra measure of structure and support for hypertext users. Students' performance while using the system was automatically collected by the program in the

form of a trace. The data collected in the trace recorded the student's review strategies by choice of theme, concepts searched, level of detail of the information accessed, and relationships among concepts. Traces contained data on theme, card name, level of depth for card, and time spent on card Material in SKEIM is linked together in a hierarchical structure, which can help users avoid some of the navigational issues associated with hypertext (Girill & Luk, 1992). Using SKEIM requires a user to begin at the highest level of detail for a theme, and through the use of pop-up menus, browse through several levels of detail about the theme; the deeper a student browses, the more detail about the topic is encountered. For example, if a user decided to explore the topic of frequency distribution, she would be presented with a pop-up menu and would then have to choose one of the following: Example, Characteristic, Leads to, Analogy, Part of, Type of, or Definition. In all, SKEIM contained 5 themes and 82 subtopics distributed through nine levels of depth.

Procedure. Participants varied in prior knowledge of the program's content and were assigned to either the low or high prior knowledge category. Within the high and low prior knowledge groups, subjects were randomly separated into two sub-groups: strong and weak accomplishment goals. Students in the strong goal group were given a specific task to complete. They were required to fill in partially completed sentences found in the hypertext database. Students in the weak goal group were given a non-specific task. They were asked to review the material in the system, and told they would be asked questions about the material when they where done.

Each student was shown how to use the program and then given his/her specific or non-specific goal to accomplish. Students were allowed to browse through the SKEIM program uninterrupted for approximately forty minutes. After the student completed the task, he/she was interviewed for approximately forty-five minutes. In order to gain insight into the students' thought processes while using the system, the researcher interviewed students using an interview guide approach.

The first part of the interview involved questions related to the subjects' feelings about use of the program in general: In what ways was navigation difficult or simple, what kind of strategy did they use, etc. Students were then shown every step they made during their use of SKEIM; this was reenacted by the program in a sort of slide show and students had the opportunity to reflect on their activity. At branching points which represented a shift in topics, the researcher asked questions to try and gain understanding about the student's immediate goal or purpose, if any, as well as any reflections on cognitive and met-cognitive activity relating to the branching decision

Results

Prior Knowledge

Students falling in the low prior knowledge category tended to find the system difficult to use. The most common complaint was in terms of navigation, especially in reference to getting lost in the system. Several students claimed that the farther they went into the program, the more they felt lost; the more details they encountered, the harder it was to maintain a navigational model. Students with prior knowledge were comfortable in navigating. Several students wanted a faster, more efficient way to navigate and none complained about feeling lost or in need of assistance while using the program. Whereas the low prior knowledge students complained about the structure of the content being different from their own, the high prior knowledge students all reported that the material was exactly what they expected; none felt their prior knowledge interfered with searching but rather made navigation simple. In response to questions about navigation, almost all felt they were able to find what they wanted easily and keep a model of the program in mind.

One seemingly beneficial aspect of a hypermedia system such as SKEIM is the presentation of a highly structured and organized set of information. For the high prior knowledge students, this characteristic was always helpful since these students already had mental models of the content but not to low prior knowledge students. Several students reported conflicts between their understanding of the content and that presented in the program. In describing her strategy during a certain part of her trace, Laurie noted:

> When I thought I knew what to expect, it usually turned out different than I expected – and that threw me off. I had preconceived notions about the grades topic – I expected material about "A's, B's, and C's" but instead found information about frequency distributions, mean, and mode instead.

Another possible problem with providing a highly structured learning environment is that there is less incentive for students to organize material on their own. Students who do not actively participate in learning activities will not benefit as much as those who do (Phye, 1997). Benny felt that the content in SKEIM was: "...organized in a way that made it seem structured – I didn't have to structure it myself. I actually would rather have created my own structure since I wanted the material organized differently."

Goals and Prior Knowledge

Students with little prior knowledge and weak goals were extremely frustrated and anxious. They followed the structure of the stack but were unsure of their actions. When low prior knowledge students had strong goals, they could not find the information they needed as they were

lacking in a conceptual model. High prior knowledge students had little difficulty and in the weak goal condition, they meandered at will in a somewhat random manner. Students in the strong goal group experienced more navigational problems. Students with little familiarity of the material found the task extremely difficult, used poorly defined strategies, and became quite frustrated. Students with higher prior knowledge were better able to perform the task, had only slightly better strategies, and were much less likely to become frustrated.

Low prior knowledge students tended to go through the material methodically, in the order it was presented. This was especially true of those students who had weak goals. High prior knowledge tended to bounce around looking to fill in gaps in their knowledge.

If I was seeing something for the first time, I didn't go too deep into detail but tried to get a more general idea. I was afraid that if I went too deep I would loose sight of what I had just learned. [Laurie]

Laurie's methodical strategy is illustrated in Table1 which contains a list of all possible nodes in the Test Scores theme, the depth for each node, and the relative order that Laurie traversed the nodes. Laurie claimed that she was extremely unfamiliar with the test scores topic, and as Table 1 reveals, she visited most of the cards in that theme and navigated basically in the order presented by the system.

Unlike the novice students, the high prior knowledge group performed the weak goal task in a fairly non-methodical manner. Their strategy, although not haphazard, was much more unpredictable. The students tended to search out of order looking for material that was either new or of interest. This tactic, however, only pertained to material that was familiar. When the students discovered new material, their strategy changed, appearing similar to the novice users' as they searched in an orderly and thorough fashion:

I usually tried to start with a topic less familiar and then went through it carefully. I realized I knew most of the material in the program so I tried to find topics I hadn't already seen. [Cory]

The trace data in Table 2, a section of the Test Types theme, reveals some of the behavior described by the students. Both Cory and Jamie visited nodes sporadically and out of order, revisiting a few nodes after exploring other topics. Danielle's behavior in this section does not match the expected high prior knowledge strategy displayed by Cory and Jamie but rather is more indicative of a low prior knowledge student; she visited the nodes in this section basically in order and thoroughly.

In general, subjects with high prior knowledge were better able to take advantage of the program's assets since for most topics, they were not learning the subject for the first time. They were able to search for new and interesting information without the fear of navigational difficulties and generally seemed more enthusiastic and encouraged by their experiences.

Table 1.
Trace Data of The Test Scores Section of Laurie's Performance

L	Theme	Topic	Link Type	Traversal Order
3	Test Scores	Standard Scores	Type of	32
3	Test Scores	Standard Scores	Characteristics	31
3	Test Scores	Standard Scores	Definition	30
4	Test Scores	Grade Equivalents	Example	29
3	Test Scores	Grade Equivalents	Characteristics	27
3	Test Scores	Grade Equivalents	Leads to	28
3	Test Scores	Grade Equivalents	Definition	26
3	Test Scores	Percentile Ranks	Leads to	
3	Test Scores	Percentile Ranks	Definition	25
4	Test Scores	Stanines	Characteristics	39
4	Test Scores	Stanines	Definition	38
4	Test Scores	T Scores	Example	
4	Test Scores	T Scores	Leads to	37
4	Test Scores	T Scores	Characteristics	36
4	Test Scores	T Scores	Definition	35
4	Test Scores	Z Scores	Example	
4	Test Scores	Z Scores	Leads to	
4	Test Scores	Z Scores	Characteristics	34
4	Test Scores	Z Scores	Definition	33
4	Test Scores	Interpret Percentiles	Example	

When questioned as to why they followed such a thorough strategy, the students explained in terms of their low prior knowledge; they generally had poor cognitive models of the material and as a result followed the model or structure presented to them by the program. This strategy was adaptive since by following the program's model, there was less cognitive overhead related to navigational factors therefore reducing the risk of getting lost.

Discussion

The study considered the influences of prior knowledge and goal specificity, focusing on students' search strategies and navigation styles but also considering students' affect toward the hypertext learning experience. The ability to trace students' search behavior can provide valuable information about the learning process. By conducting in-depth interviews, we were able to investigate some of the affective as well as cognitive reactions to non-linear text processing. Results show that students tended to have more than just a cognitive reaction when learning from hypertext. High levels of anxiety were common for the low prior knowledge students especially when they were required to perform a specific learning task. The implications to these findings are that hypermedia design aspects, which in interaction with specific individual characteristics

such as prior knowledge and goals, can promote negative affect which is known to be non-productive for learning.

Table 2.
Trace Data Of The Test Types Sectic For The Three High Prior Knowledge/Weak Goal Students for Theme "Test Types".

L	Topic	Link Type	Traversal Order		
			D	C	J
4	Criterion-Referenced	Characteristics	37		
4	Criterion-Referenced	Example	38		24
4	Criterion-Referenced	Leads to			
4	Criterion-Referenced	Definition	36		21
4	Norm-referenced	Example	35		
4	Norm-referenced	Characteristics	34		
4	Norm-referenced	Leads to	33		
4	Norm-referenced	Definition	32		
4	Achievement tests	Example			22
4	Achievement tests	Type of	31		20
4	Achievement tests	Characteristics	30		23
4	Achievement tests	Definition	29		19
4	Standardized tests	Characteristics	24		
4	Standardized tests	Example	39		
5	Uniform Conditions	Characteristics	26		
5	Uniform Conditions	Example			
5	Uniform Conditions	Leads to	27		
5	Uniform Conditions	Definition	25		
5	Essay Tests	Characteristics	47	3	6
5	Aptitude Tests	Characteristics			
5	Aptitude Tests	Definition	28		18
5	Multiple Choice	Characteristics	44	19	
5	True False	Characteristics		17	
5	Multiple Choice	Leads to		22	
5	Multiple Choice	Part of	43	18	

This study contributes to the previous literature by considering how learning goals affect hypermedia users. The results of this study suggest a relationship between subjects' level of prior knowledge and desired goal. This relationship was most noticeable in relation to students' search strategies and navigational styles. The low prior knowledge students performing the strong goal task had complaints about navigation and generally stated that they would have benefited from the use of a navigational aid. In general, they were unsuccessful at their task, suffering more seriously as a result of cognitive overload, frustration, and poor ability to navigate than did those novices simply wandering through the system. The high prior knowledge students suffered much less from negative affect and were somewhat more successful at completing the strong goal task. The task was easier for these students since they already had a mental model of the content and had some idea where to look for an answer.

These findings suggest that developers of educational software should seriously consider features of the audience before committing to a method of instructional delivery. A system designed to teach novices might be more effective if it used techniques geared toward introducing students to a subject rather than a hypertext format. In general, hypermedia systems should be designed to accommodate users of different levels of prior knowledge. A hypermedia system designed for an audience varying in subject expertise should provide as many resources as possible, since novices will probably require them and experts might benefit from their presence.

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